ORTHOPEDIC

ED.08

BASIC ANATOMY AND PHYSIOLOGY OF BONES

----- Active space -----

Bone composition & markers

00:00:38

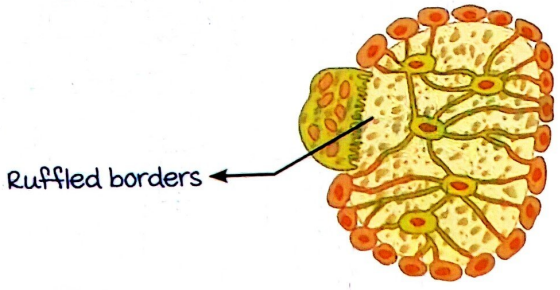
COMPOSITION

Bone (osteon)

- Organic component/ Osteoid
  - Cells
    - Osteoblast
      - Cell type :
        - Mononuclear cells
      - Function :
        - Lays down osteoid matrix (collagen)
          - ↓ mineral deposition
          - Bone/Osteon
      - Rich in Alkaline phosphatase
    - Osteoclast
      - Cell type :
        - Monocyte aggregates.
        - Multinucleated giant cells.
      - Function :
        - Phagocytic.
        - Bone resorption & remodelling.
      - Rich in TRAP & carbonic anhydrase.
    - Osteocyte
      - Cell type :
        - mature/resting osteoblast.
      - Features :
        - Most abundant.
        - Longest life span.
  - Proteins
    - Collagen : Type I (Principle protein).
    - Osteocalcin.
    - Osteonectin.
- Water :
  - ↑ in children
  - (bones → softer).
- Inorganic component :
  - Calcium hydroxyapatite (principle mineral).

Note : Collagen types

Type I	Type 2
• Bones. • Meniscus. • Annulus fibrosis.	• Articular hyaline cartilage. • Nucleus pulposus.



- Strength of bone depends on osteoblasts & osteoclasts.

2 Orthopaedics

----- Active space -----

BONE MARKERS

markers

Bone formation
- Alkaline phosphatase (ALP)
- Procollagen I
- Osteocalcin
- Osteonectin

Bone resorption
- Hydroxyproline, Hydroxylysine } Collagen breakdown products
- N&C telopeptide
- TRAP

Anatomy

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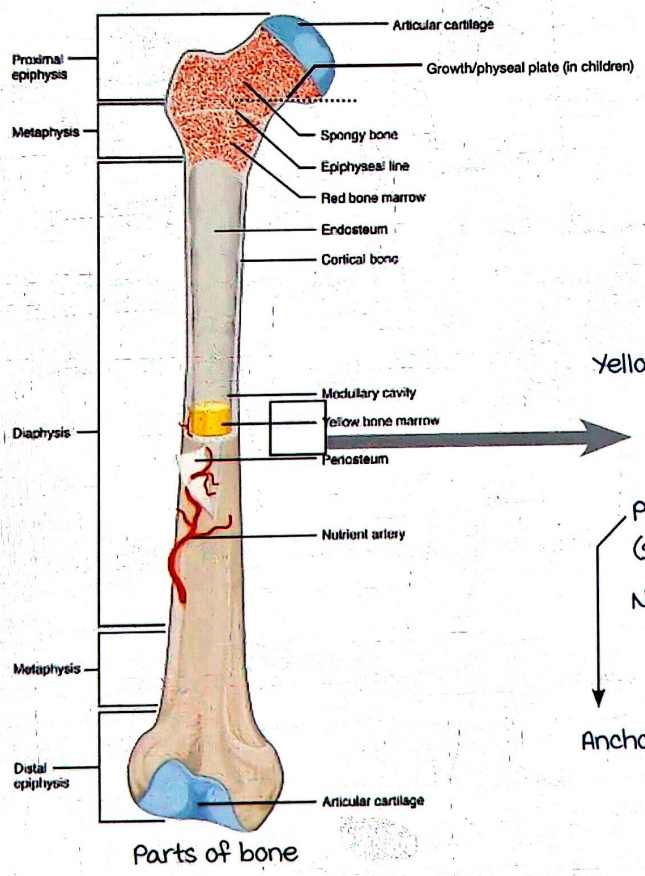
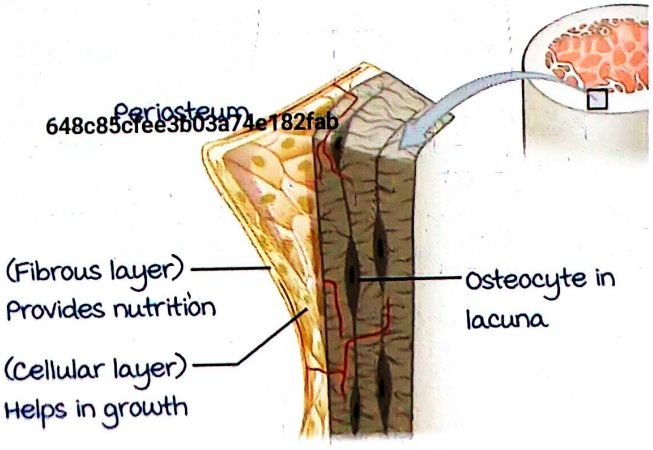


Parts of bone

medullary cavity :
Content :
- Children : marrow.
- Adults : Fat.

Anchors periosteum to bone



Periosteum :
- Present in all long bones
- Absent in :
  - Articular surface of long bones.
  - Sesamoid bones (eg : Patella).

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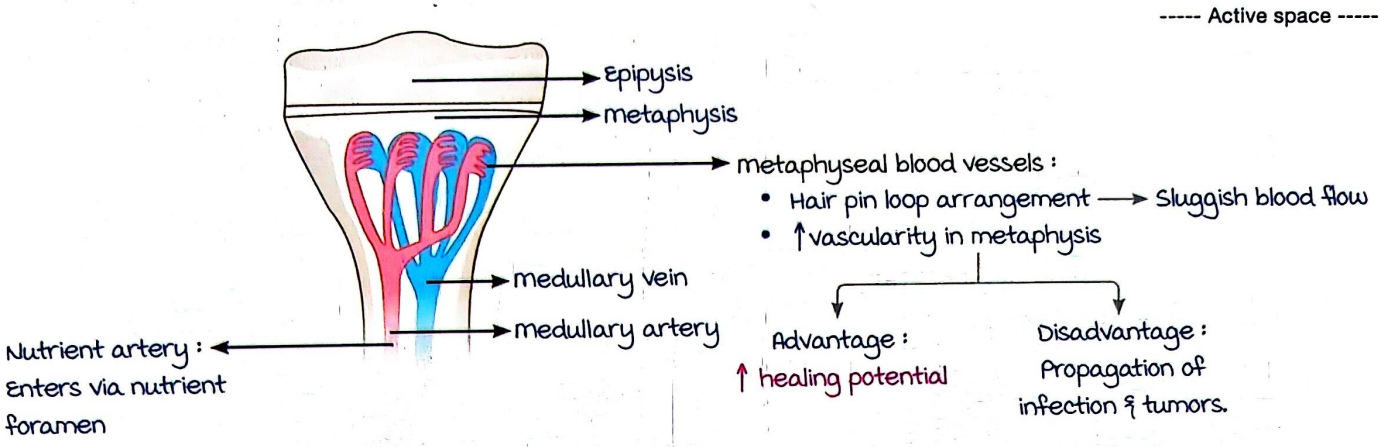

Note : metaphysis has very few macrophages/monocytes.

TYPES OF BONE ARCHITECTURE

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Immature woven bone :

- Improperly arranged collagen.
- Weak.
- Seen in :
  - Children.
  - Bones healing from fracture (eg : callus).

Mature/lamellar bone :

	Cancellous/spongy	Cortical/compact
Site	metaphysis	Diaphysis
Consistency	Soft	Hard
Bone cells	↓	↑
Vascularity	↑	↓
Fracture healing	Fast	Slow
Risk of infection	↑	↓
Fracture complication	malunion	Non union

Note :
Epiphyseal fractures (Intraarticular) → Osteoarthritis → ↓ Range of motion.

Feedback

----- Active space -----

Bone Growth

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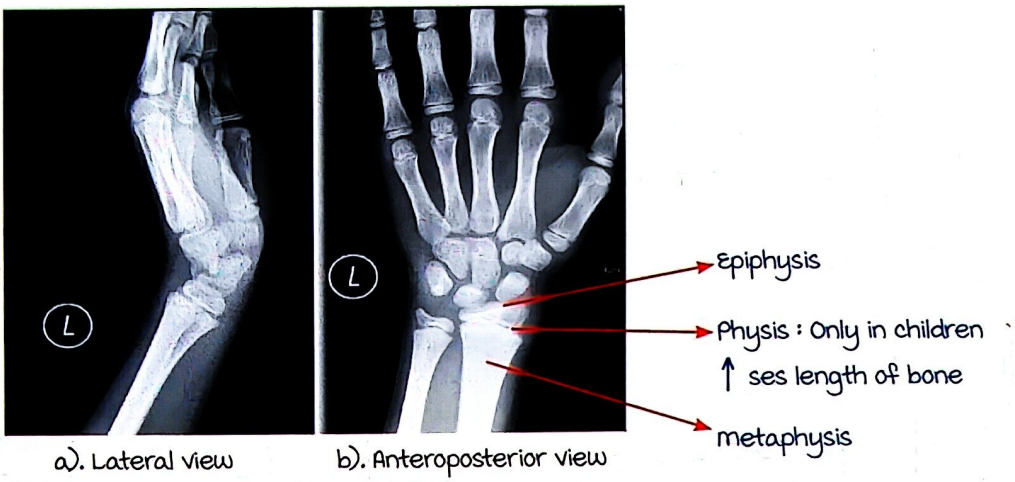
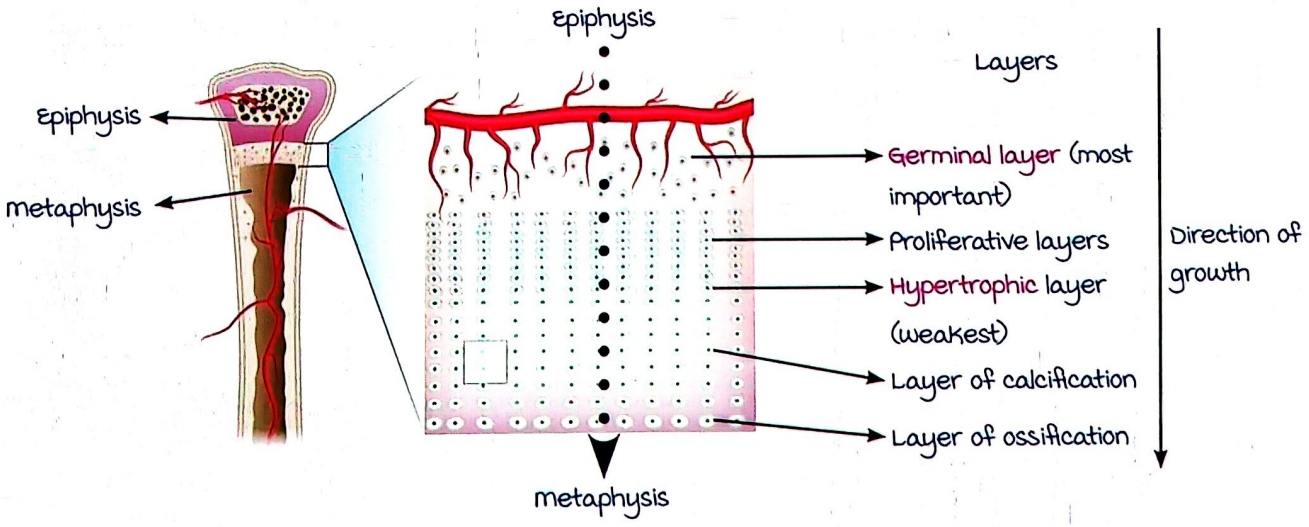


a). Lateral view b). Anteroposterior view

X-ray : Left hand (child).

Growth plate structure :



Applied aspect :

Growth plate (germinal layer) injury

- Complete
  - I/L side (bone) : Stops growing.
  - C/L side (bone) : Continues to grow.
    - Limb length discrepancy
- Partial
  - Asymmetrical growth
    - Deformity (varus/valgus)

Appositional growth (↑ses thickness) : By endosteum & periosteum.

BASIC TERMINOLOGY OF FRACTURE AND HEALING

----- Active space -----

Fractures

00:00:49

Break in continuity of bone cortex

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GENERAL FEATURES OF FRACTURE

Clinical signs :

- Abnormal mobility at fracture site > crepitus (Pathognomonic).
- Tenderness (most consistent).
- Swelling.

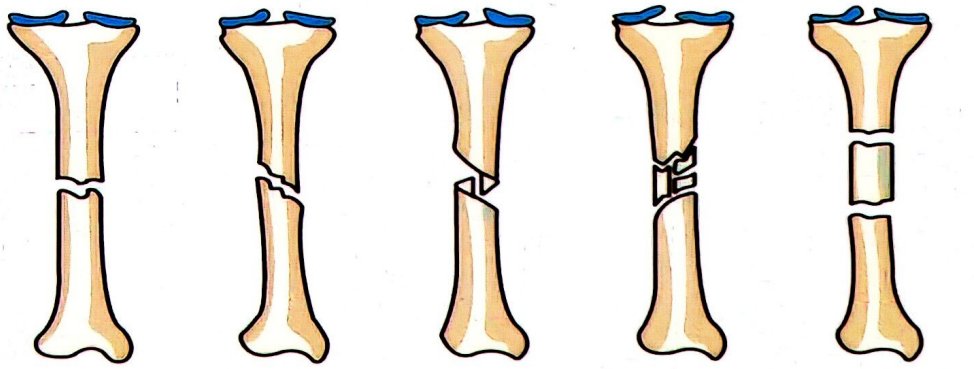
Radiological :

- X-ray : Discontinuity of bone.

CAUSES

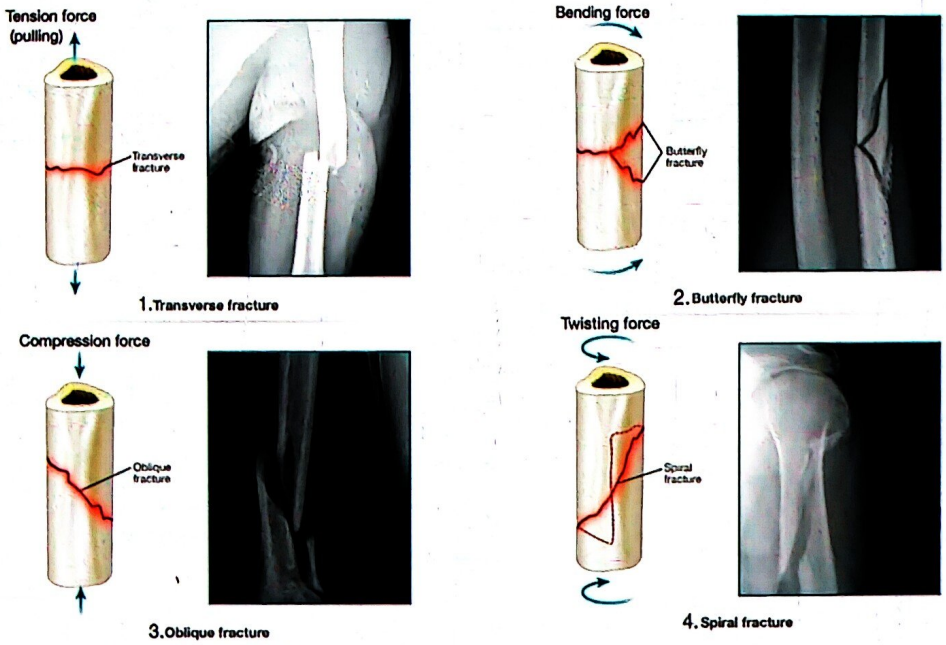
Fractures with significant trauma :

Types :



1. Transverse 2. Oblique 3. Spiral 4. Comminuted 5. Segmental

Mechanism of injury :



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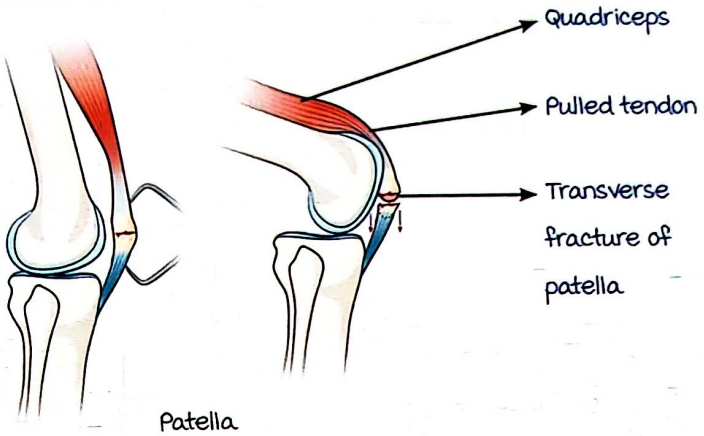
Avulsion fractures :

- Violent pull of tendons → Avulsion of bone.
- Eg : Patella, olecranon.



Patella

Fractures without significant trauma :

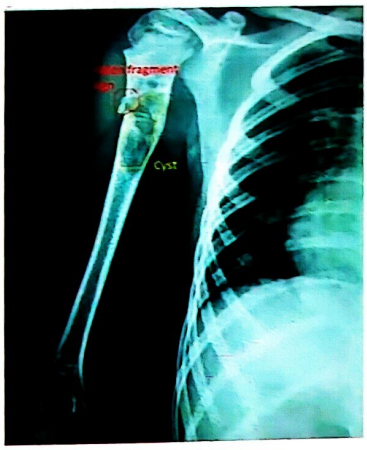
Pathological fractures

Localized causes

- Infection.
- Ischemia.
- Lesions.
- Cysts.
- Radiation.

Generalized causes

- Osteoporosis (m/c cause) :
  m/c sites : Spine > hip > wrist (Colle's).
- metastasis :
  - m/c site : Proximal femur.
  - Ix : FDG-PET
- Osteomalacia.
- Rickets.
- Osteogenesis imperfecta.
- Paget's disease.
- Scurvy.



Fracture 2° to cyst

Fracture 2° to Paget's disease

- Pain before the fracture (d/t micro fractures).
- Investigation :
  - X-ray : Shows primary lesion.
- management :

A. Mirel's criteria :

- used to predict risk of pathological fracture d/t lesions.
- Score of ≥8 : Requires prophylactic fixation with internal fixation devices.

B. Treat underlying cause.

Basic Terminology of Fracture & Healing 7

Stress fracture :

- D/t sudden & repetitive loading of bone.
- Common sites :
  - a. Tibia.
  - b. Fibula.
  - c. metatarsal (march fracture) :
    - 2nd > 3rd metatarsal.
    - Neck > shaft.

  } weight bearing bones

- Pain :
  - Prior to fracture.
  - ↑ on activity.
- Investigations :
  - X-ray : Fracture visible after 2-3 wks of symptoms.
  - MRI (IOC) :
    Identifies → Soft tissue edema.
    Identifies → Occult fractures.
  - Bone scan : For multiple stress fractures.
- Management :
  - Stop the stressors.
  - Immobilization of affected limb.

March fracture


Runner's fracture

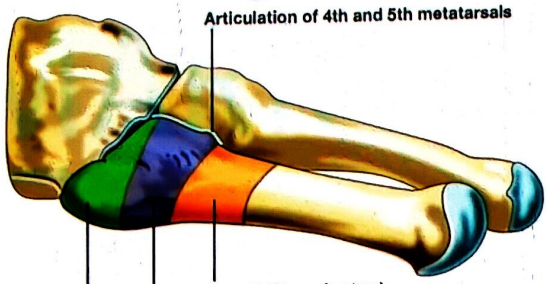
Shin splints :

AKA Medial Tibial Stress Syndrome (MTSS).

- Seen in runners.
- Medial periostitis of tibia.
- Mechanism of injury :

Repetitive muscle contractions → inflammation of periosteum at site of muscle attachment → Pain over anteromedial side of leg

- X-ray : Normal.



Robert jones fracture

Note :

Robert jones : Fracture of 5th metatarsal base.

Feedback

----- Active space -----

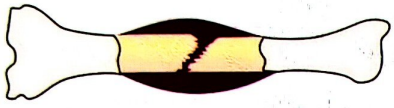
Fracture healing

00:18:25

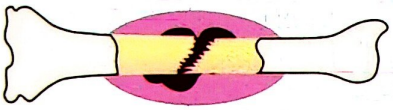
TYPES OF FRACTURE HEALING

Primary	Secondary
• Direct healing	• Indirect : Callus (Cartilage) formed first → bone
• D/t absolute stability (rigid fixation)	• micromovement at fracture site (+)
• No callus seen	• Stronger
	• more common

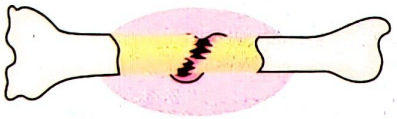
1. Hematoma formation (2-3 days)



2. Granulation Tissue Formation (Inflammation) (2-3 weeks)



3. Callus Formation (2-3 months)



4. Consolidation (2-3 years)

5. Bone remodelling (3 years)

STAGES OF FRACTURE HEALING (2°)

Nutrient artery ruptures

↓

Bleeding at fracture site

↓

Stage I : Collection of blood (hematoma)

↓

Causes release of chemotactic agents that attracts fibroblast

↓

Stage II : Fibroblasts forms fibrous meshwork (Granulationtissues) between the fracture fragments

↓

Fibroblasts differentiate into osteoblasts.

↓

Stage III : Osteoblasts lays down osteoid matrix and minerals to form callus

↓

Stage IV : Callus hardens.

↓

Stage V : Resorption by Osteoclasts to resemble native bone.

Callus :

----- Active space -----

- Disorganised mass of immature bone.
- Visible on X-ray after 2-3 weeks of fracture.

Note : compression at fracture site → promotes union.

FACTORS INHIBITING FRACTURE HEALING

- Patient
  - Old age
  - Malnutrition
  - Tobacco consumption
  - Alcohol consumption
- Type of fracture
  - Open
- Tissue
  - Ischemia
- Treatment
  - Improper mobilisation (m/c)
  - Inadequate reduction

Complications in fracture healing

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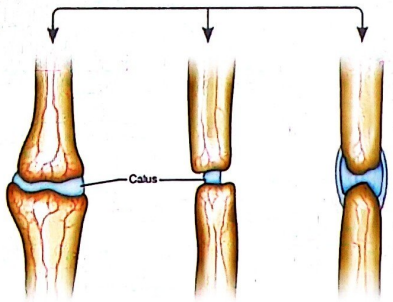
NON-UNION

- Callus formation absent for > 9 months.
- Risk factor : Diaphyseal bone fractures.
- m/c site : Lower 1/3rd Tibia.

Types :



Hypertrophic Oligotrophic Atrophic

Differences between Hypertrophic & Atrophic Non-Union :

	Hypertrophic	Atrophic (typical)
Ends of fracture	Smooth & sclerosed (↑ density)	
Fracture line	Visible	
X-ray appearance		
Callus formation	↑↑	Absent
Bone biology	Good	Abnormal
Immobilisation	Improper	±
Treatment	Immobilization	Autologous bone grafting

Feedback

----- Active space -----

Bone Graft :

m/C source : Iliac crest.

Ideal bone graft characteristics :

1. Osteogenesis : Graft itself makes bone using osteoblasts.
2. Osteoconduction : Allows bone to grow on it as a scaffold.
3. Osteoinduction : Stimulates surrounding host bone to form bone (Growth factors : differentiates mesenchymal cells → bone forming cells).

Substitutes of bone graft :

Property	Substitute
Bone conduction	• Calcium phosphate • Calcium sulphate • PMMA (Poly methyl methacrylate)
Bone induction	Bone morphogenic protein (improves bone union)

MALUNION

- Fractures healing in anatomically abnormal position.
- Rx : Osteotomy (Bone realigned & fixed if functional abnormality (+)).

Note : Bones with ↑ risk of malunion vs non-union.

Malunion	Non-union
• Clavicle (m/c) • Supra-condylar humerus • Colles • Intertrochanteric (extracapsular) femur	• Lower 1/3rd of tibia (m/c) • Scaphoid • Lateral condyle of humerus • Neck of femur (intracapsular) • Neck of Talus

Fractures that undergo malunion, rarely/never undergo non-union (& vice-versa).

Management of Fracture

00:36:42

Important Terms :

Displacement : Movement of distal fracture segment d/t pulling forces by muscle.

Reduction : Bringing fracture segment back to normal anatomy with counter-forces.

Traction : Counter-force applied.

Fixation : Maintaining fracture in reduced position till it heals.

REDUCTION

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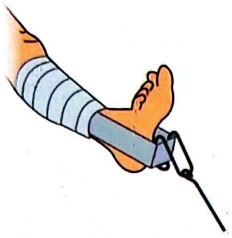
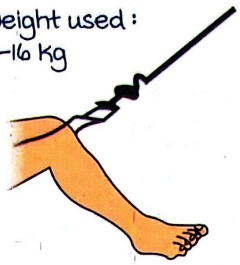
Methods :

1. Manual reduction



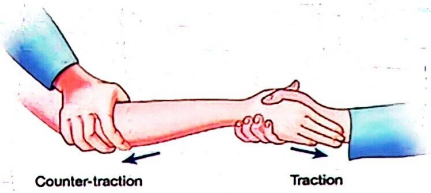
Weight used : 5-6 Kg

2. Skin traction



Weight used : 15-16 Kg

3. Skeletal traction



Manual closed Reduction :

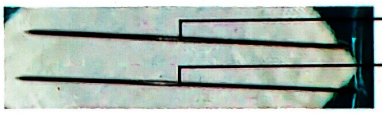
- Done using manual 'traction' and counter traction.
- Followed by POP application.
- Repeat X-ray to confirm reduction.

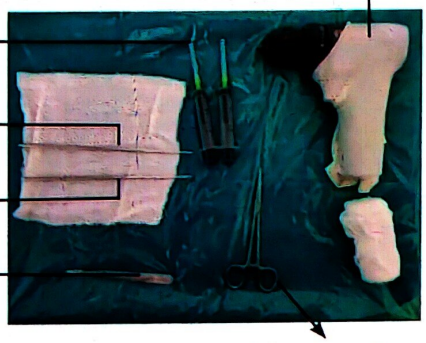
Skin traction :

Bandage wrapped → Force on bandage → Force on skin → Force on soft tissue → Maintains fracture reduction

Skeletal traction :

Site of pin → Proximal tibia (1cm/).
- Lower tibia.
- distal femur.
- Proximal femur.





Bohler stirrup

Instruments used for skeletal traction

Feedback

----- Active space -----

		Denham pin	Steinmann pin
Threading		+	–
Indications	1. Type of bone fractured	Osteoporotic	Normal
	2. Site of traction	Calcaneal	Tibia / femoral

Procedure (upper tibial skin traction) :

1. Site : Draped and prepared.
2. Local anesthetic given : Bone deep on either side of bone laterally.
3. Stab wound → 2.5 cm below and behind tibial tubercle.
   → made using No. 11 scalpel reaching bone (to avoid friction while inserting pin).
4. Dilate entry site using artery forceps.
5. Pin placed in drill and inserted into entry wound.
6. Pin drilled through the bone and brought out at opposite site.
7. Drill removed and wound dressed.
8. Böhler's stirrup mounted onto pin and locked.
9. Weights applied using ropes.
10. Patient mounted onto a splint.

Complications :

- Staphylococcus aureus infection : m/c infection at pin traction sites.
- Pin-tract sequestrum : ring shaped sequestrum at entry & exit sites.

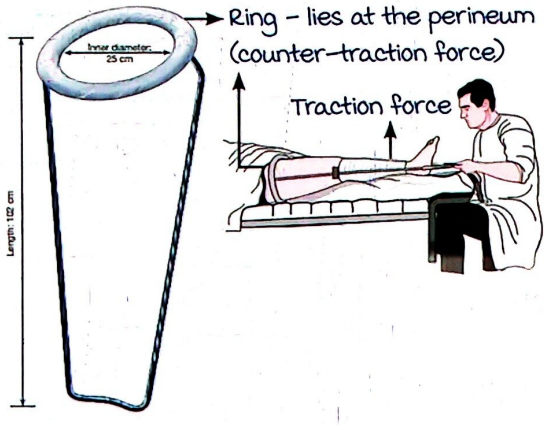
Uses : for traction of lower limb fractures : Intertrochanteric, Distal femur.

TEMPORARY MANAGEMENT : SPLINTS

To stabilize fracture.

Thomas splint :

- Inventor : H.O Thomas.
- First use : to treat TB Knee.
- Fixed traction device (has both traction & counter-traction forces).
- Advantage : Patient mobility (+).
- Indication : lower limb fractures (m/c : femur fractures).



Feedback

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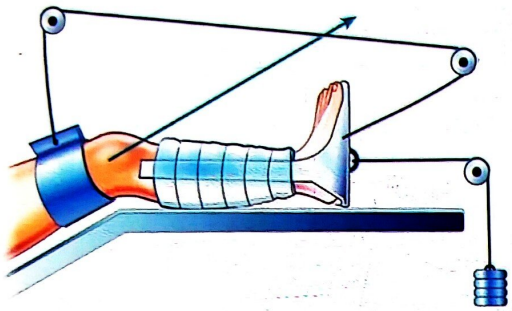
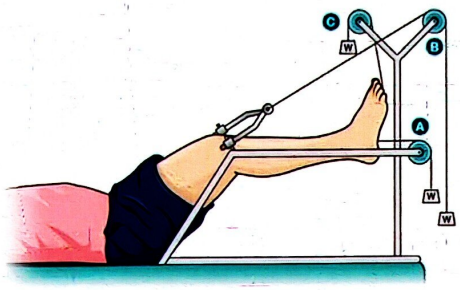
Bohler & Braun Splint :

----- Active space -----

- Sliding traction device used in wards.
- Force : Traction : Weights
  Counter traction : Gravity(footend of bed raised)
- Location of pulleys :
  - A : For Tibia fractures.
  - B : For Femur fractures.
  - C : To prevent foot drop.



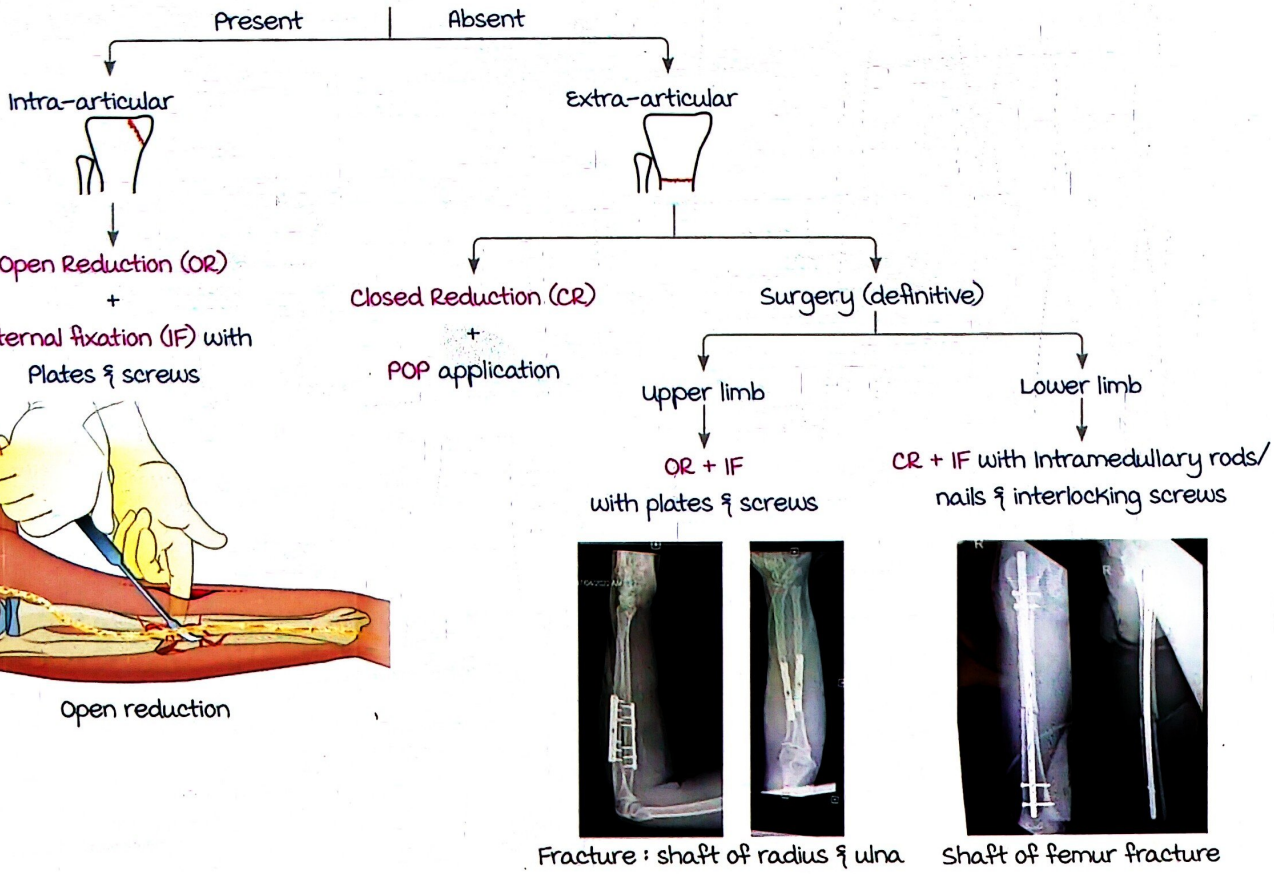
Russell's Traction
Indication : Inter-trochanteric fracture of femur



Bohler & Braun splint : location of pulleys

DEFINITIVE TREATMENT

Algorithm : Assess for involvement of articular surface.



Open reduction

Fracture : shaft of radius & ulna

Shaft of femur fracture

Feedback

Reduction → Open : Fracture visualised and reduced
Reduction → Closed : Done without opening fracture site and confirmed with X-ray

Accuracy of reduction : Open > closed

↓

Hence preferred in intra-articular fractures (to prevent osteoarthritis)

POP application :

Disadvantages	Advantages
• Cumbersome • Requires joint immobilization above & below fracture → Disuse atrophy, Stiffness	• Non-invasive • Cheap • Easy application & removal

CR+IF :

Reduction : using C-arm (image intensifier)

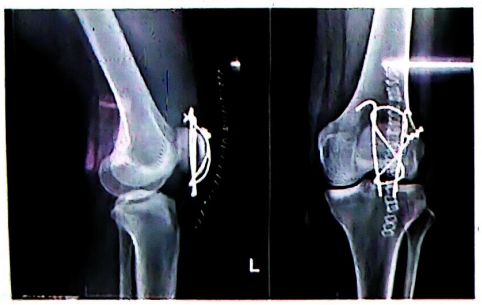
Fixation : Rod/nail passed into the bone medullary cavity

↓

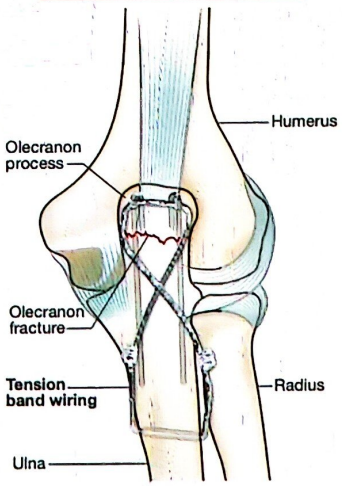
interlocking screws placed (to avoid rotation of rod)

Fractures due to avulsion forces :

Patella fracture
(d/t Quadriceps pull)



Olecranon fracture
(d/t Triceps pull)



Rx : OR + IF with Tension Band Wiring (TBW)

OPEN FRACTURE, AMPUTATIONS AND POLYTRAUMA

----- Active space -----

Open fracture

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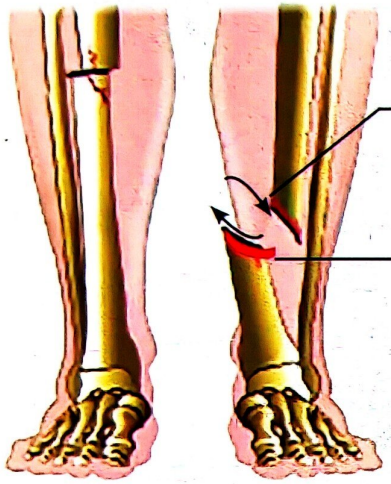
- Fracture + break in skin and underlying soft tissue.
- m/c involved : Tibia and phalanges.

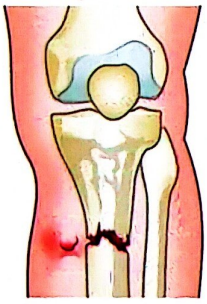
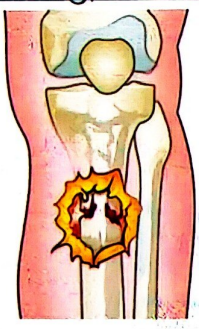


→ Communication with the environmental pathogens (m/c : Staphylococcus aureus)

→ Fracture hematoma escapes outside

} affects healing

GUSTILO ANDERSON CLASSIFICATION

Type I	Type II	Type IIIa	Type IIIb	Type IIIc
				
• Wound <1cm long. • Cause : D/t impingement of fracture fragments on skin. • AKA inside out injury.	Wound 1–10 cm	Open fracture + contaminated environment : sewage, farms or firearm injury.	Open fracture with periosteal stripping	Open fracture + vascular injury

Usually > 10 cm

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----- Active space -----

MANAGEMENT

Wound management (more important) :

1. Antibiotics

2. Wound toilette :
   - Wound wash : Povidone iodine & sterile NS.
   - Wound debridement.

3. Wound closure :

Primary closure :

Only in clean wounds where the edges are approximating

+

Satisfactory debridement

Secondary/delayed closure :

- If > 6 hrs – 12 hrs (golden period).
- Associated neurovascular injury.
- Edges cannot be approximated.
- Not satisfied with debridement.

4. Wound healing : manage like a closed fracture.

Fracture :

Grade I : managed like closed fracture.

Grade II, IIIa :
- If clean (<6–12 hrs) → manage like a closed fracture.
- Otherwise like open (external fixation).

Grade IIIb, IIIc : External fixation (immobilization/stabilization of bone outside the body).

Note : Internal fixation is C/I in open fractures.
Placing a device inside the bone → growth of organisms & biofilm formation → Infection.

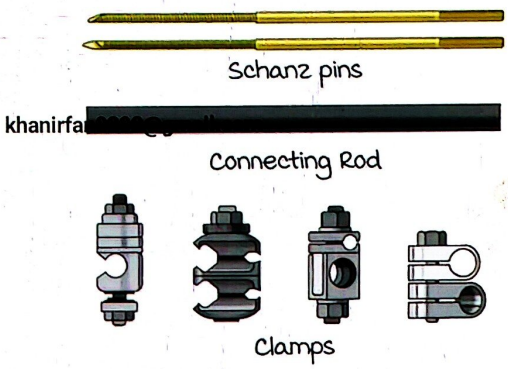
External Fixation

00:07:47

Fixation of bone outside the body.

Schanz pins
- Placed proximal and distal to the wound
- They immobilize the bone

Rods to immobilize the pins



Feedback

Stability :

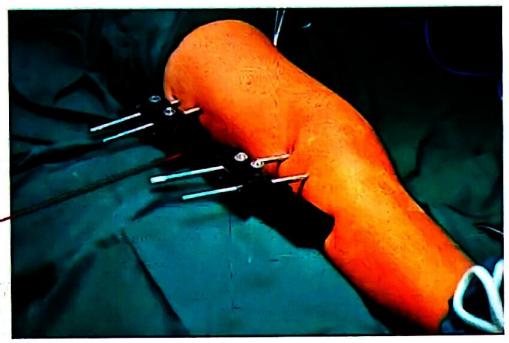
----- Active space -----

↑ stability by :

- ↑ number of pins.
- ↑ number of rods.
- ↑ number of planes used to stabilize the fracture (Biplanar > uniplanar).

TYPES

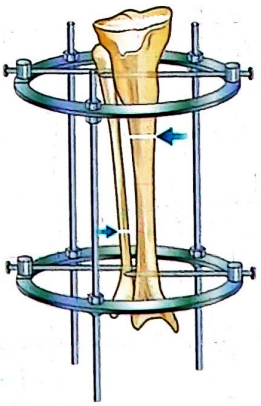
1. Rail fixator/Limb reconstruction system :



Adjustable rods : Combination of compression & external fixation

2. Ilizarov ring fixator :

- multiplanar
- most stable external fixator.
- Allows for compression and distraction of fracture site.
- Pins can be put in any direction.



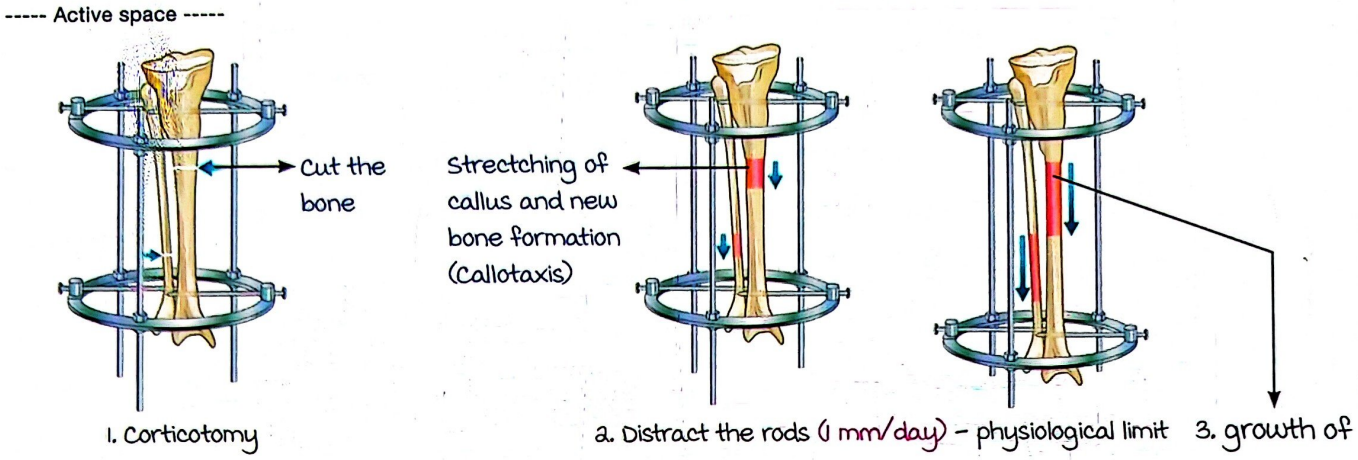
multiplanar system

Distraction Osteogenesis :

Done in open fractures with bone loss.

Indications :

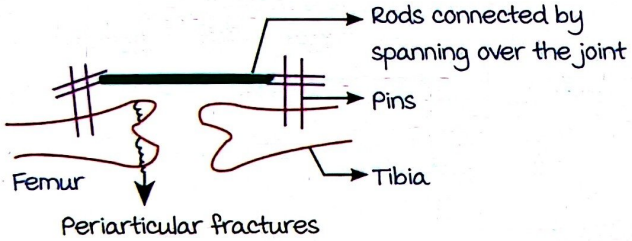
- Open fractures.
- Non union.
- Infected non union.
- Deformity correction or malunion.
- Fracture with bone loss.
- Limb lengthening.



3. Spanning external fixator :

Uses : Periarticular open fractures.

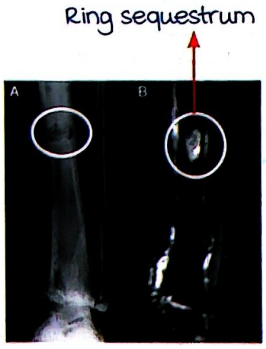
Eg : Side swipe injury/baby car injury.




Spanning external fixator

Complications :

Necrosis of site where pin is placed (infection/heat d/t drilling).



Note : Compartment syndrome.

- Equal incidence in high and low energy injuries.
- Can occur in open fractures.
- High index of suspicion and be vigilant in patients with altered level of consciousness.

Amputation

00:19:50

Damaged limb/contaminated/not salvageable

Amputation :
Cutting the limb off the body through the bone

Disarticulation :
Cutting the limb off the body through the joint

Feedback

Indications : Dead, dangerous or dumb limbs

----- Active space -----

- Crush injury/RTA.
- Peripheral vascular disease (PVD) like diabetes mellitus.
- Frost bite, gas gangrene, malignant tumour.
- Congenital absence of limb/neuromuscular disease like polio.

Trauma scores :

1. Mangled extremity severity score (MESS) : Score ≥ 7 = Amputation.
   - V : Velocity of injury or soft tissue coverage.
   - I : Ischemia time (most important).
   - S : Shock.
   - A : Age of patient.
2. Limb salvage score
3. Ganga score

Types :

1. Closed amputation :

Skin is closed in 1° surgery.

2. Open or guillotine :
   - Skin is kept open after amputation & closed in 2nd stage.
   - Indications :
     - Infected/contaminated stump.
     - Amputation for ischemic conditions.

Principles :

1. Use of tourniquet : Reduces bleeding
   C/I if cause of amputation is ischemia or PVD.
2. Structures cut :
   - Amputation : Everything is cut.
   - Disarticulation : Sparing of bone.
3. Bone has to be cut 5cm shorter than soft tissue.
4. Double ligate the vessels.